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Since computational procedure, processing equipment, and techniques are inert, nonhuman phenomena, only the man can be held accountable for decisions. There are three major limitations to the use of quantitative techniques in decision making: (1) The techniques used must be applicable to the problem and must reflect the purpose and scope of the problem, (2) the extent to which quantitative techniques are maximally useful to a decision maker is directly proportional to the expertise of the people he must depend upon to develop them, and (3) the consequence of the problem must be defined within limits, thus limiting the applicability of the results. Since man is accountable for the final decision, judgments regarding the value of any decision, plan, or procedure cannot be easily built in to any quantitative system. Precaution should be taken, therefore, not to limit decisions solely to those dictated by quantification. (HW)

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SOME LIMITATIONS AND CAUTIONS IN THE USE OF QUANTITATIVE TECHNIQUES IN DECISION-MAKING

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SOME LIMITATIONS AND CAUTIONS IN THE USE OF QUANTITATIVE TECHNIQUES IN DECISION-MAKING*

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Let me begin by pointing out that the most precautionary aspect surrounding the use of quantitative techniques in support of administrative decisions is an obvious one; I would put it in this fashion: since computational procedure, processing equipment, and technique are, in and of themselves, inert, non-human phenomena, only the man can be held accountable for the decision. Now that is, at once, both the major strength of the use of quantitative techniques and the major limitation, for all other admonitions must derive from this fundamental one. Just as the power of quantification vastly improves the precision with which optimality can be achieved, it decreases the decision-maker's familiarity -- his involvement -- with the elements of the decision-making process and therefore tends to accentuate the abruptness of his confrontation with accountability. In a sense, this merely states in a somewhat oblique fashion, the more familiar dialectic which has and continues to take place with reference to the place of values and valuing in the "quantified society". I will return to this major issue toward the end of this paper for it seems to me that a topic such as this one must both begin and end with this molar kind of concern of the quantitative as over and against the qualitative.

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Of somewhat more molecular interest, there are, as I see it, eight areas under which limitations and cautions might be articulated with reference to the use of quantitative techniques in decision-making. These might be subsumed under the major headings of limitations of applicability, expertise, and consequence.

Consequence

I begin with the last of these first, for limitations imposed by consequence are also somewhat axiomatic -- at least to the extent that we can all agree that predictability is seldom finite; to state the premise that, all other things being reasonably equal, quantitative precision enables one to reduce the probability of the unintended consequence, logically assumes that the unintended consequence can indeed occur. Put more simply, we can observe that if there is only one viable alternative, no decision process, whether intuitively vague of mathematically exact offers anything additional to the choice.

For an empirical illustration, remember that few commercial decisions in recent years were rationally planned more thoroughly in American industry than the introduction by the Ford Motor Company of the Edsel.

Consequences and Antecedents

Another dimension of the problem of consequence is the requirement that an analyst must begin with an already established set of consequences of other antecedent decisions. It is seldom that we are able to deal with problems in a de noveau fashion; more likely, we turn to the seeking of more objective, quantitative devices after problems are already well-developed and some kinds of decisions have already reduced the degrees of freedom available at that point. An interesting example of this situation is illuminated by events surrounding the seizing of the Pueblo; by the time the President was clearly aware of the action taken by the

North Koreans, whatever alternatives available to him were limited by the decisions already made at lower echelons. Thus, an important limitation to the use of any objective process for problem-solving is the set of given conditions that must be considered. It is for this reason that we have to be satisfied with "optimal" solutions -- and as you are aware, these are merely the best solutions under the circumstances. Clearly then, the circumstances must represent a significant limitation.

Applicability

One important aspect of limitations of consequence ties closely with limitations of applicability; if applicability is misjudged, then obviously consequences are going to be completely unintended. And if decisions are rendered on the basis of inappropriate applications of a technique, then they are not going to be good decisions and are not going to have predicted consequences. This is not always so clear-cut as it may seem. Consider the situation in which a board of education and its executive staff confront the problem of the need to construct a building. Assume that by some appropriate and reliable method, the decision to construct a building is arrived at and is one upon which there is complete conviction and confidence. Now obviously, this decision generates the need for hundreds of additional ones, many of which are consequential and many of which are inconsequential. At least one of the consequential decisions concerns strategies of securing enough community support to provide the resources for constructing the facility. In this case there are two very different tactical alternatives. For lack of something better to call these, let us label one tactic "efficiency" and the other "effectiveness." In an oversimplified way of characterizing the natures of these two tactical alternatives, suppose we assume that the board can either think in terms of the long range

by designing a facility for low maintenance costs over time, or not give too much consideration to maintenance costs and go for the lowest possible initial costs in order to stand a better chance of getting the facility.

In this case, the use of quantitative techniques will very likely dictate in favor of efficiency for that is the nature of quantitative phenomena. There are all kinds of arguments in favor of efficiency in this case -- even basic values about thrift and quality-control and so forth indicate that the better decision is high initial cost, low maintenance costs. But having arrived at this alternative, the board may, using equally objective data and quantitative techniques, have another alternative available which says in effect that if you go for high initial costs you confront a 50/50 risk of having the bond issue turned down, whereas if you go with low initial costs you only run, say, a 40/60 risk of failure on the issue. What is the criterion of decision? If it is a conviction that the need is great enough, then the optimal decision is the lower risk; but if that conviction is not that substantial and one wants sincerely to provide the best instructional space possible, then the other decision is perhaps optimal.

Now, in both situations, it is possible to apply certain kinds of quantification techniques. But with the tactic of "efficiency" one can be more comfortable with the measurement of variables for he is dealing with a greater number of components which lend themselves to quantification and, in addition, the accessibility to, and retrieval of, the measurable data in the case of "efficiency" is more convenient. The entire quantitative process is more parsimonious. But when one is confronting the probabilities of whether a particular set of specifications is or is not marketable, he is dealing with a much more fluid mathematical environment. Too many of the

components that he must build into his system do not lend themselves to easy quantification. Such components are likely to be characteristically idiosyncratic to a unique decision environment. The analyst must therefore assign weights to his various components. When one performs this activity, he engages in a process whereby an attempt is made to objectivity otherwise subjective judgements. So long as he is consciously aware of what he has done, he may proceed (albeit timidly) to pursue the particular logic involved in simulating the course of events that is probable. However, there is ample evidence to suggest that many of us fall into the trap of forgetting that our "weights" are little more than beta-values and begin to think of them as exact quantities. That is an error of noble dimensions. Again, the applicability of a procedure is dictated by the consequences expected. In this case -- and many others -- the final decision is influenced by the judgement, intuition, experiences, and, sometimes, sentiments, of the people who will be held accountable. These are qualitative phenomena. In some way, any decision must be qualified.

Applicability and Purpose

I suppose that the major point that I want to make then in this regard, is to emphasize the major difference between those conditions in which the inputs, operations, resources, and outputs are easy to quantify and those other situations in which the opposite is true. The purposes to be served are of immense importance. In this connection, I remember an old story that is instructive; there was a man who was interested in knowing more about an objective approach to hiring personnel and who had a friend well experienced in this area. This friend invited

the man to sit in while he interviewed a number of applicants for a stenographic position. The personnel expert asked each prospective candidate for the position a number of complicated questions noting each response very carefully. After the series of interviews, he turned to the man who had watched the process intently and said to him, "Now you have heard all of the questions and the answers given; which one would you choose?" The man gave it only a moment's thought and then said, "Why, I would choose the one with the nice legs." No one would argue that well-proportioned legs do not lend themselves to easy quantification but surely there is some intrusion of valued purpose into that decision.

Applicability and Scope

Again with reference to problems of applicability, there are some limitations and restraints forced upon quantification by virtue of the scope of the problem. As can be concluded from other papers in this symposium, the greatest success in the use of various quantitative techniques has been achieved when sub-units of the total system have been the primary target, and furthermore, when utility is most defensible. For example, we can solve certain school transportation problems more satisfactorily using linear programming techniques than simple experience, even, if the experience is substantial and meaningful. Such a procedure is highly efficient in helping us to determine rather precisely the nature of equipment needs in terms of the kind, size, number, and even optional accessories required. But that same technique may not be at all appropriate when we confront the problem of trying to determine where, when, and how each bus must go. It is my understanding that attempts to use linear programming to the latter problem have not yielded.

satisfactory results; operations researchers, having generally recognized such limitations, are seeking solutions through different procedures. Graph theory, for example, according to some specialists, may provide much more appropriate techniques.

Problems of Expertise

Just as problems of applicability are closely related to limitations of consequence, the applicability issue is also closely related to limitations of expertise. In this context, there is always the limitation of know-how. If linear programming is the only technique one knows then the utility of the service rendered is substantially reduced. Moreover, that lack of sophistication can be compounded many times over if one knows only this one technique but tries to apply it to all kinds of problems. Associated with that is a condition that might be characterized as "measurement myopia." This condition may be suspected whenever a manager begins to observe that his systems people suggest quantitative techniques for attacking anything remotely problematical, or in more advanced stages, when he discovers that they no longer seem able to communicate with anyone except each other. There is clear and present danger that having reached this stage of "measurement myopia" a procedure becomes more important to the technician than its product. In very advanced stages, a particular procedure becomes obsessive and unless a problem lends itself to that particular technique, the analyst may choose disdainfully to have nothing to do with it. He will respond by asserting that, "The problem does not excite me."

To deny that this is a potentially real shortcoming is to forget how conversationally narrow the typical graduate student can become at that point where

he really begins to get going on his thesis topic. It is remarkable to him that anyone could possibly be enthused about, or care to discuss, anything else.

The extent to which quantitative techniques are maximally useful to a decision-maker is directly proportional to the versatility of the people he must depend upon to develop them. To this extent, I might also point out that one is limited clearly by the hardware available for processing one's data and -- expertise again -- the versatility of programmers.

The Problem of Time

There is a final limitation to quantitative procedures -- they require time and in many decision situations, there isn't enough of it. Sir Richard Livingston who was vice-chancellor of Oxford, once described administrative work by pointing out that it:

> ". . . consists in being pushed by events, finding immediate answers to immediate questions, and the difficulty (being), behind their urgency, to remain aware of anything ultimate, to avoid mortgaging the future."[1]

Finding immediate answers to immediate questions too frequently precludes a rational survey of the situation and renders codification of appropriate responses impossible.

Qualitative vs. Quantitative: The Problem of Values

Thus far in this paper, I have attempted to characterize some of the limitations that impinge upon the use of quantitative techniques; hopefully, if the paper is useful, readers will have thought of others that have not been mentioned.

At this point, I want to return to the caution that I expressed at the beginning of the paper -- that only men are accountable for decisions regardless of how they are arrived. The implications of this fact of human accountability are primarily qualitative; that is, judgements regarding the value of any decision, plan or procedure cannot be easily built-in to any quantitative system if they can be built-in at all. Several years ago, John Wilkinson discussed this problem as follows:

> 'Quantity' may be defined as a species of geometrical extension, which can be measured or counted, and whose syntax is mathematics and logic, 'Quality' is value as felt. That this definition of quality is unsatisfactory illustrates the principal thesis . . . , namely the exclusion of valued quality from rational discourse. The reason for this is that our mathematical and logical systems can only refer to qualities if they are quantified, that is, if they have ceased to exist as qualities as such. Price is an example of quantity, value of quality. How little connection price may have to value is often painfully clear . . . In a computerized society values as such cannot get into the mathematical language of the computer network. The numbers that are supposed to express value turn out to have a very ambiguous relationship to valuational feelings.[2]

Mr. Wilkinson's paper stirred considerable controversy and I recommend it to you; what he reminds us of is the fact that the quantification of information makes it possible for man to measure the order or disorder extant in a system. On the basis of this, he proposes that the ". . . more ordered a social system becomes from the quantitative point of view, the more disarrayed it becomes from the quantitative point of view, the more disarrayed it becomes qualitatively."[3]

Perhaps another way of saying something like that is to suggest that the more ordered any kind of system becomes, the more monolithic it must be for the simple reason that it is immensely difficult -- and at this point, I would guess, impossible -- to put values into mathematical systems in a multidimensional fashion.

Whitehead once implied the nature of this dilemma when he observed two wine glasses on a table and said:

> "One and one make two. One and one what? One glass, or one partly filled? One and one where? On a table, in this room, or in this universe? But two glasses are not and cannot possibly be made exactly equal. Nor can they be filled with equal amounts of wine. Then do we mean 'one plus one' after all of the necessary deductions and additions have been made? But the glasses are also raging with molecular activity . . . and we must remember that (they) are disintegrating before our very eyes. I refuse to be taken in by such monstrous inexactitude . . ."[4]

In a real sense, then, we must cautiously remember that the use of quantitative procedures requires the making of "necessary deductions and additions", and though we may say they constitute x number of the former, and y number of the latter, this ability to enumerate the number of deductions and additions, precise though it may be, tells us absolutely nothing about the ways they have changed the procedures we propose to use or the utility of their application.

The decision to apply quantitative techniques in decision-making is itself a value judgement of sizable dimensions and is dictated by qualitative assessment of the purposes it can serve. Purposes cannot be determined by quantitative techniques -- only the means available to us for their most proficient pursuit can be. Betrand Russell suggested the same thing when he pointed out that:

> "Broadly speaking we are in a race between human skill as to means and human folly as to ends. Given sufficient folly as to ends, every increase in the skill required to achieve them is to the bad. The human race has survived hitherto owing to ignorance and incompetence, but given knowledge and competence combined with folly, there can be no certainty of survival . . . unless men increase in wisdom as much as in knowledge, increase in knowledge will be increase in sorrow."[5]

The availability of emerging techniques in the use of quantitative concepts and procedures for assisting managers in the solution of administrative problems

is a most significant developmental advance; judicious and appropriate use of such techniques will undoubtedly provide avenues for vast improvements in all of those activities which facilitate educational achievement. But we should occasionally remind ourselves of the obvious -- the major precaution in the use of such procedures is that we must be careful not to limit ourselves to them, and more important, not to be limited by them. We must continue to emphasize that purposes and the processes by which purposes are defined must guide our behaviors. The use of any set of skills is always a matter of fundamental perspective.

NOTES

1. Lucian Price, Dialogues of Alfred Worth Whitehead, Boston: Little, Brown, and Company, 1954, p. 305.

2. John Wilkinson, "The Quantitative Society or - What Are You To Do With Noodle?" Occasional Paper, Center for the Study of Democratic Institutions, Santa Barbara: The Center, 1964, p.2.

3. Ibid., p.2.

4. Price, op. cit., pp. 329-330

5. Bertrand Russell, The Impact of Science on Society, New York: Simon and Schuster, 1953, pp. 97-98.